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| 6. AUTHOR(S)<br>Professor Charles M. Marcus | | |
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13. ABSTRACT (Maximum 200 words)

The original aim of this MURI was to combine an experimental effort to develop tools to manipulate quantum coherence in the solid state, based on metallic wires, quantum point contacts, and the quantum Hall effect, with theoretical efforts aimed at understanding device architectures and the information capacity of quantum channels.
The Marcus group aims to develop locally controlled magnetic fields in the vicinity of quantum point contacts and to develop novel heterostructure-based spin detectors. Both Marcus and Yamamoto have investigated the so-called 0.7 structure as a means of generating spin filtering properties and are actively pursuing the use of this feature in a quantum point contact as a spin filter.
Marcus has demonstrated that the magnetic orientation of the gates can be flipped using on-chip current lines.. Yamamoto is presently working to realize this device in a Hall-bar geometry in a high mobility GaAs heterostructure.
Gershenson has focused on the role of electron spin in the 2D metal insulator transition, which may have important implications for 2D spin-tronic transisitors in semiconductors.

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## (3) List of Figures

## (4) Statement of the Problem Studied

The original aim of this MURI was to combine an experimental effort to develop tools to manipulate quantum coherence in the solid state, based on metallic wires, quantum point contacts, and the quantum Hall effect, with theoretical efforts aimed at understanding device architectures and the information capacity of quantum channels.

## 5) Summary of most important results

Two important advances occurred during the course of this funding. The first was the development of a technique to fabricate semiconductor quantum point contacts using ferromagnetic gate material. This will allow controllable local magnetic fields to be imposed on a quantum point contact. A picture of a device fabricated by the **Marcus** group is shown in Fig. 1.

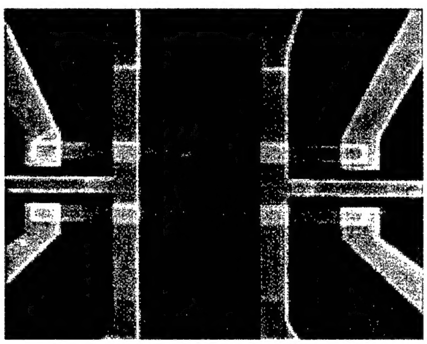

**Fig. 1.** A pair of point contacts made from permalloy (yellow) with control lines (blue) that can set the orientation of the magnetic moment. This can function as a polarizer-analyzer pair.

This work is continuing, and has been extended to include hard magnetic materials. A scanning Hall probe showing the ability to flip the magnetic domains is shown in Fig. 2. This demonstration shows that in-situ control of local magnetic fields on a chip can be realized.

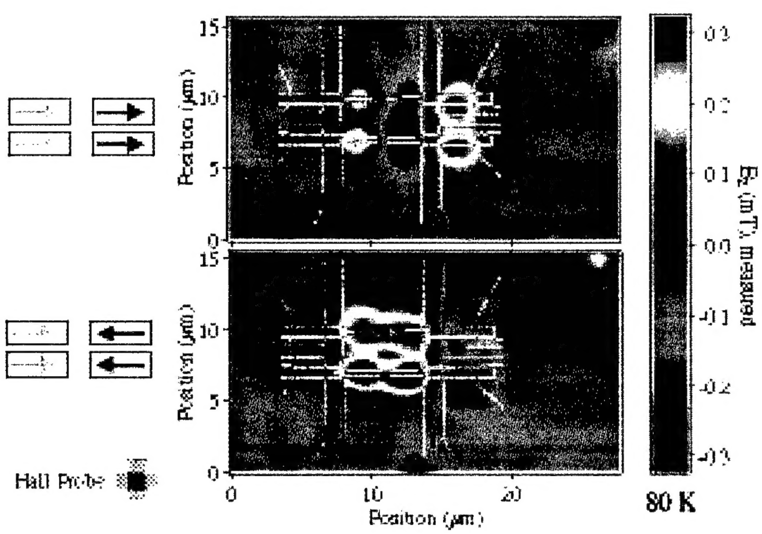


**Fig. 2.** Scanning Hall probe micrograph demonstrating that the permalloy point contacts can be flipped in situ. This work was done in collaboration with the Molar Group at Stanford.

The second important development is the refinement of ideas about how to use edge states in the quantum Hall regime as a test of quantum locality (i.e. the Bell inequalities). This work, by the **Yamamoto** group has been published in Physica E.

Using ultra-thin superconducting films, **Gershenson** has developed a method of accurately measuring electron-phonon scattering times, founding $\tau_{e\text{-}ph} \propto T^{4}$, a signature of the disorder-modified electron-phonon interaction. This research sheds light on the electron-phonon interaction in nanostructures, where the electron mean free path might be comparable to the phonon wavelength even at room temperature.
This work has important potential applications. Our observation of a record-long $\tau_{e\text{-}ph}$ at low temperatures (25 millisecond at 40 mK) implies that the sensitivity of the state-of-the-art direct detectors of submillimeter and infrared radiation can be increased by two orders of magnitude.

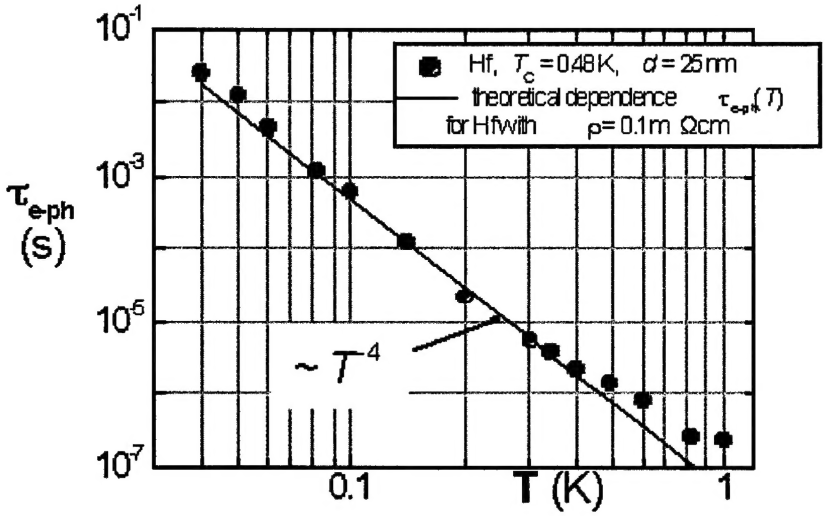


**Fig.3.** Electron-phonon scattering time in a metallic wire. This is the longest measured e-ph time, and confirms the $T^4$ law predicted for disordered systems. From Gershenson.

## (6) List of Manuscripts published under ARO sponsorship:

J. A. Folk, S. R. Patel, K. M. Birnbaum, C. M. Marcus, C. I. Duruoz, J. S. Harris, Jr. Spin Degeneracy and Conductance Fluctuations in Open Quantum Dots, Phys. Rev. Lett. 86, 2102 (2001).

Xavier Matre William D. Oliver, Yoshihisa Yamamoto, Entanglement in 2DEG systems: towards a detection loophole-free test of Bell's inequality, Physica E **6** 301 (2000).

M. E. Gershenson, Yu. B. Khavin, D. Reuter, P. Schafmeister, and A. D. Wieck, Hot-electron effects in two-dimensional hopping conductivity with a large localization length, Phys. Rev. Lett. 85, 1718 (2000).

B. S. Karasik, W. R. McGrath, M. E. Gershenson, and A.V.Sergeev, Photon-noise-limited direct detector based on disorder-controlled electron heating, J. Appl. Phys. 87, 7586-7589 (2000).

M. E. Gershenson, Low-temperature dephasing in disordered conductors: experimental aspects, Annalen der Physik 8, 559-568 (1999).

## (7) Scientific Personnel:

1) Scientific Personnel:

*Senior Personnel:*
Charles M. Marcus
Yoshihisa Yamamoto
Thomas Cover

Martin Morf
Michael Gershenson

*Graduate Students:*
Sara Cronenwett, Ph. D. student, Stanford
William Oliver, Ph. D. student, Stanford

**(8) Report of Inventions:**

None that resulted from ARO-sponsored research.

**(9) Bibliography**

**(10) Technology Transfer**